Role of Remote Sensing and GPS In Site Specific Crop Management

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Abstract- *Remote sensing technology plays an important role in site specific crop management and introduces new opportunities for improving agricultural practices. The purpose of site specific crop management allows farmers to manage the field in an individual grid zone with respect to its unique output potentialities. The art of managing the field in an individual grids or zones is being pertained as site-specific farming. This technology is framed to render broad reliable information and data to help the crop growers for making better site-specific management decisions. By having more modified and improved management decisions, growers can turn into more efficient, lower production costs, and in turn, more remunerative. This new technology is also possible by using of inputs in a précised manner, linking computers, on-the-go sensors, Global positioning systems Geographical information system and Yield monitoring systems. Hence, this paper provides an overview of precision agriculture and its technologies.*

Keywords- Precision, Agriculture, innovative, information, technology

I. INTRODUCTION

Precision agriculture is a new emerging, highly promising technology, spreading rapidly in the developed countries. Precision agriculture is a scientific endeavour to improve the agricultural management by application of information technology (IT) and satellite based technology (e.g. global positioning system, remote sensing, etc.) to identify, analyze and manage the spatial and temporal variability of agronomic parameters (e.g. soil, disease, nutrient, water, etc.) within field by timely application of only required amount of input to optimize profitability, sustainability with a minimized impact on environment. As the result of information technology application in agriculture, precision farming is a feasible approach for sustainable agriculture. In view of the wide gap between the potential and actual yield levels in the developing world necessitates for promoting PF to achieve the intended benefits (food demand for future generation in our country).

Precision farming envisages a threefold advantage. First, it provides the farmer useful information, that can influence their use of seed, fertilizer, chemicals, irrigation and other farm inputs. Second, economics are optimized by enhanced efficiency of farm inputs. Finally, by varying the amount of farm inputs (fertilizers, pesticides and irrigation) used for crop production, and applying those inputs exactly where they are needed, the environment is sustained (Strombaugh and Shearer, 2000).

Remote sensing is becoming a useful tool for precision farming, using scanners on aircraft or satellites to monitor changes in wavelengths of light from fields and growing crops. Satellite imagery is also useful in more precise mapping of field boundaries and location of tile drainage lines, for example, and is often most effective when used in conjunction with field scouting ("ground truth observations") to help identify the reasons for variability. The data collected can be mapped and analyzed with the help of GIS tools, to provide additional data layers for GIS analysis and management decisions.

Remote sensing helps to define the extent of problems identified in field scouting by recognizing similar patterns. It is used to document such issues as pest problems, weather factors, nutrient management issues, and more. While it has taken several years to develop remote sensing technology to the point of providing dependable, cost effective products and services in a timely fashion, there are now such services available to add to the toolbox to aid farmers and their advisors in making crop management decisions.

Precision farming technologies

Precision farming (PF) technologies for site-specific crop management offer a way to manage the sub-field variability of soils, pests, landscapes and microclimates by spatially adjusting input use to maximize profits and potentially reduce environmental risks. These technologies involve geo-referencing, which allows producers to micro-manage soil and plant processes within small areas of a single field. Precision agriculture tools are used to monitor crop yields, to apply inputs at a variable, rather than at a constant rate and to guide equipment. These tools are used to determine soil electrical conductivity, manage soil on a site-specific basis and to monitor crop growth and health from satellite or aerial images. All of these tools use GIS to acquire process, analyze and transform the data that farmers can use to better manage production and increase profitability. GPS units are used to guide equipment during chemical and irrigation applications and during harvest (Adrian *et al.,* 2004).

1. Yield monitoring and mapping

Yield is ultimate pointer of variation of different agronomic parameters in different parts within the field. So, mapping of yield and correlation of that map with the spatial and temporal variability of different agronomic parameters used to develop the next season's crop management strategy (Mondal *et al*., 2004). Yield differences within fields are due to factors such as differences in soil fertility or unequal application rates of fertilizers or biocides, the presence of compacted layers, low and wet spots or high and dry spots, pests and diseases, etc. Once reasons have been established, site-specific management procedures must be devised which allow local rectification of differences.

Present yield monitors measure the volume or mass flow rate to generate time periodic record of quantity of harvested crop for that period (Plant, 2001). Time periodic yield data is then synchronized with location address obtained from onboard GPS system to create most common colour coded thematic map (Pierce *et al*., 1997). Grain yields are measured using four types of yield sensors-impact or mass flow sensors, weight-based sensors, optical yield sensors and γ-ray sensors. Commercial yield monitors currently available to farmers are based on a wide variety of measurement methods including a paddle wheel volume flow sensor, a momentum plate sensor, a gamma ray sensor, strain gage based impact sensors, and an infrared sensor. Other sensors reported in the literature include a pivoted auger, piezo-film strips, a capacitative sensor, an ultrasonic sensor, an elevator based flow sensor and x-ray techniques. Properly calibrated field monitor systems are generally very accurate (<1 to 5% error) at estimating yield averages over large areas (Pierce *et al*., 1997).

To determine yield, two parameters then need to be measured: grain mass and harvested area.

Grain mass determination**:** A yield sensor provides a flow signal proportional to the amount of grain in the measurement volume. Data from the flow sensor, moisture/density sensor, slope sensor and the clean grain elevator data are used by the yield monitor to obtain a flow signal. The resulting flow signal can be expressed as the amount of grain per unit time (kg/s), which can be related to yield (kg/ha) when merged with area data.

Area measurement**:** Combine ground speed and cut width sensors are used to determine the harvested area per unit time. These data are recorded instantaneously with the flow data. Combine ground speed can also be measured by using a DPGS unit, which would eliminate the need for a ground speed sensor for yield mapping. Combine location is recorded periodically with the location determination system. This allows one to calculate the distance the combine travels in a given time. Knowing the distance and time, the forward speed of the combine is calculated. The product of the distance travelled in a given time and the cut width provides the area harvested.

Location determination**:** The location of the combine head is determined by using a DGPS receiver.

Mapping yield**:** The yield data and the location data are merged together to generate the yield map using mapping software. The processed data are depicted as color-coded visual representations of yield values. These variations can be shown as dots, blocks, or contours in the yield map. The visual observation of yield variations in a map is informative, but quantitative analysis is required for a proper interpretation of the processed yield data for spatially selective applications. It is clear that yield mapping can offer the basis for variable rate applications in crop.

II. VARIABLE RATE TECHNOLOGY (VRT)

Variable rate technology combines GIS, GPS and electronic controllers in the cab to change the rate of any product being applied in the field. In general terms, VRT is accomplished by developing a prescription map, transferring it to the controller in the cab of the vehicle, driving the field with the controller changing the application rate based on the prescription map and recording how much was applied where. VRT also can be done on-the-fly with sensors that measure what is needed by the crop and adjust the rate accordingly in real time.

Variable Rate applications

There are many applications that can be applied with varying rates. There are as many controllers available that can change the output of an electric over hydraulic pump, electrically driven feed rollers, mechanical gate or pressure valve. Most of these can accept a rate input from a controller to adjust the rate. Integrated control systems have been developed that work across farm equipment so that they can be shared between combines, tractors and variable-rate equipment. This allows a farmer to obtain a single, cost efficient system that can be implemented in many field operations (Dampney and Moore, 1999).

Site-specific nutrient management

Fertilizer application recommendations are often based on crop response data averaged over large areas, though farmers' fields show large variability in terms of nutrient-supplying capacity and crop response to nutrients. Uniform application of fertilizers, therefore, can result in under-fertilization of certain parts of a field and over-fertilization in other areas (Frasier *et* al., 1999). Under-fertilization may result in a yield loss and over-fertilization can be harmful to the environment (Cambouris *et al*., 1999). An alternative to blanket guidance, Site-Specific Nutrient Management (SSNM) aims to optimize the supply of soil nutrients over time and space to match the requirements of crops

- ***Right rate:*** Match the quantity of fertilizer applied to crop needs, taking into account the current supply of nutrients in the soil. Too much fertilizer leads to environmental losses, including runoff, leaching and gaseous emissions, as well as wasting money. Too little fertilizer exhausts soils, leading to soil degradation.
- ***Right time:*** Ensure nutrients are available when crops need them by assessing crop nutrient dynamics. This may mean using split applications of mineral fertilizers or combining organic and mineral nutrient sources to provide slow-releasing sources of nutrients.
- ***Right place:*** Placing and keeping nutrients at the optimal distance from the crop and soil depth so that crops can use them is key to minimizing nutrient losses. Generally, incorporating nutrients into the soil is recommended over applying them to the surface. The ideal method depends on characteristics of the soil, crop, tillage regime and type of fertilizer.

The most widely used form of VRT is variable-rate fertilizer application (Cambouris, *et al*., 1999). With the invention of VRT, it has become possible to manage soil nutrient variations throughout a field with prescription fertilizer applications. Kholsa *et al*. (2001) reported that the optimal delineation of site-specific management zones (SSMZ) on farm-fields into regions of high, medium, and low productivity based on inherent soil properties insures that the crop in each SSMZ has the required level of N needed to maximize yield in that specific zone.

Site-specific weed management

For decades, farmers have uniformly broadcast or band applied herbicide to decrease yield loss due to weed competition, reduce weed seed contamination in harvested grain, and improve crop harvestability (Johnson *et al.,* 1997). In a century of increased concern over environmental issues and the need for higher input efficiency, uniform application of chemical herbicides may be replaced with a site-specific form of herbicide application. Pressure to reduce food, soil and water contamination and increased herbicide costs have prompted the need for precision technologies to target herbicide application more accurately. Thus, provides a higher degree of optimization in herbicide use (Stafford and Miller, 1996).

Timmermann *et al*. (2001) conducted a 4-year experiment in five fields of wheat, barley, sugar beet and corn in the area of Bonn, Germany. Weeds were sampled in grids and then maps were created with the software UNPROG. Herbicide application followed three strategies: whole field spraying, band spraying and site-specific treatment. They found that herbicide savings differ by crop and year, but overall results show an average saving of 54% in herbicides (or 33 Euros ha^{-1} in monetary value). They also found a decrease in environmental damage, due to less around and surface water contaminated with herbicides. The authors also reported that similar studies in site-specific weed control allowed herbicide savings of 47–80% (Nordmeyer *et al*., 1997) in cereals and of 42% in corn (Tian *et al*., 1999).

Clay *et al*. (1998) recorded the spatial variability of weeds in a soybean field in South Dakota and used it as input information for a bio-economic weed control model to generate pre-emergence, pre + post-emergence and post-emergence herbicide strategies at three field locations. They concluded that site-specific herbicide application and placement optimized economic returns and environmental safety, benefiting the producer and society.

Heisel *et al*. (1996) reported herbicide savings of 66–75% in site-specific weed control field tests in barley, in Denmark, compared to normal recommendations. This reduction exceeded the goal of the Danish Ministry of Environment, which was to reduce pesticide use by 50% in the period 1987–1997. Stafford and Miller (1996) found that targeting herbicide application to grass weed patches in cereal crops in the United Kingdom resulted in a 40–60% reduction in herbicide use. Khakural *et al*. (1994) found that there was a decrease in alachlor concentrations in surface runoff from soybean fields as a result of SSM in a fine loamy catena in south-western Minnesota. By adopting site-specific rates of alachlor application instead of applying a uniform rate in the entire field, alachlor concentration in runoff water, sediment and water + sediment was reduced by 10%, 24% and 22%, respectively. The concentration of alachlor in runoff water was less from application of SSM (2.20 or 2.80 kg ha^{-1}) than from uniform management (3.66 kg ha^{-1}).

Site-specific pest management

Some insecticides are non-selective and their extensive use affects natural enemies and other non-target organisms in the fields. Leaving unsprayed sites in the fields can give refuge to natural enemies and to susceptible individuals of the target pest. Site-specific integrated pest management (SSIPM) is a strategy that can be used to achieve this goal (Midgarden *et al.* 1997). SSIPM uses spatial distribution maps to specify application of control measures in those parts of the field where population density exceeds the economic threshold (Pedigo, 2004). Determining the spatial distribution patterns of pests is a pre-requisite for SSIPM programmes. SSIPM is applicable in cases where pest population distribution is aggregated in space (Park *et al.* 2007).

Weisz *et al.* (1996) conducted 2 years of trials in rotated commercial potato fields in Pennsylvania to compare traditional whole-field IPM with site-specific IPM for Colorado potato beetle (Leptinotarsa decemlineata [Say]), green peach aphid (Myzus persicae [Sulzer]) and potato leafhopper (Empoasca fabae [Harris]). In the whole field treatment, insect controls recommended by the IPM program were applied to the entire field when the mean pest density exceeded thresholds. In the site-specific treatment, insect controls were similar, except that controls were applied only to specific within-field locations. Pest sampling and mapping was performed weekly, and at the end of each season, statistics were calculated. Overall results indicated that SSM reduced insecticide inputs by 30–40% compared with whole-field integrated IPM, across a broad range of colonization pressures.

Variable depth tillage

The utilization of large heavy equipment has resulted in excessive compaction of soil that has been associated with decreased crop yield. It is relatively common for farmers who face this kind of problem to subsoil fields where compaction is suspected and/or heavy vehicles have operated. A major problem in this case therefore will be reliable determination that such compaction exists and if so, selecting the most advantageous means of dealing with the problem. The soil cone penetrometer has been used extensively to determine soil strength that indicates the likelihood of poor root growth and crop performance. This instrument provides a relatively rapid measurement of soil strength versus depth and as such, can determine both the location and depth for which tillage is needed.

As the concept of GPS-based precision agriculture has gained acceptance, the idea of precision tillage has evolved to include real-time control of a ‘smart’ tillage tool (Scarlett *et al.* (1997) and variable-depth deep tillage (Raper, 1999). Precision deep tillage is attractive from the standpoint of eliminating unnecessary tillage. Evans *et al.* (1996) reported no improvement of corn yield resulting from sub-soiling and suggested that it can be used only when compaction is evident. Threadgill (1982) showed that the loosening effect of sub-soiling was temporary, suggesting that regular deep tillage would be required to achieve beneficial results as indicated by Raper *et al.* (1998). Ahmad Khalilian *et al*., (2011) conducted an experiment to study the advantage of variable depth tillage over conventional tillage (Table 2). This study reported that 56.4% total saving in energy and fuel consumption over conventional tillage system and also time required for tilling the soil is reduced in VDT.

III. CONCLUSION

Future Precision Agriculture will be a progeny of these two technologies with a rich heritage of relatively old, satellite based technologies of last century. Precision farming has created scope of transforming the traditional agriculture, through the way of proper resource utilization and management, to an environmental friendly sustainable agriculture.

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